WRIGHT

On the Anatomy of Microphallus Opacus Ward a Distome of Fresh Water Fish

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ON THE ANATOMY OF MICROPHALLUS OPACUS WARD A DISTOME OF FRESH WATER FISH

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Sewall Green Wright

ENTITLED On the Anatomy of Microphallus Opacus Ward A Distome of Fresh Water Fish

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE OF Master of Science in Zoology

Henry B. Ward
In Charge of Major Work

Henry B. Ward
Head of Department

Recommendation concurred in:

Committee on Final Examination

ON THE ANATOMY OF MICROPHALLUS OPACUS WARD
A PARASITE OF FRESH WATER FISH

Introduction

This investigation has been carried on with material furnished by Dr. H. B. Ward from the type specimens of Microphallus opacus in his possession, which were collected by him in 1893 from certain fresh water fish in Lake St. Clair - Amia calva, Ictalurus punctatus and Perca flavescents. They were fixed in corrosive sublimate. I was unable to use toto mounts to any great extent, owing to the great development of the vitelline glands and uterus which conceal the other organs. Most of the work was done with sections, transverse, frontal and segittal, 5-20 thick, and stained on the slide with Delafield's or Ehrlich's haematoxylin.

This species was first described by Ward in 1894 as Distoma opacum. Stossich in 1899 included it in his new genus Levinsenia, which, being preoccupied, was changed by Styles to Levinseniella. It was removed to a new genus Microphallus by Ward in 1901. It belongs to family Microphallinae of the distomes which includes the four genera, Microphallus, Levinseniella, Spelophallus and Spelotrema.

General

This is a small pear shaped distome, being very thick in proportion to its breadth. The thickness in the anterior region where there is little but parenchyma, is not nearly as great as

that in the posterior which is packed with organs. A frontal section cutting both ends is usually quite elliptical, while a median sagittal section is somewhat wedgeshaped, small end forward. The length varies between 1.0 and 2.0 m.m. The averages of length, greatest breadth and greatest thickness are about 1.5 x 0.8 x 0.6 m.m. The ratio of thickness to breadth changes with the size of the animal. In small ones it is practically 1.0 in larger ones 0.6. These dimensions are a little less than those given by Ward, viz., length 1.6-1.7, breadth 1-1.16. This is true of all of the measurements taken.

Suckers, Integument and Digestive Tract

The most conspicuous objects on the external surface are the two suckers, oral and ventral. The ventral sucker is buried in the body so that its lips are even with the surface and is placed in the median line of the ventral surface a little back of the middle. It has the ordinary shape, i.e., a sphere from which a small hemisphere, reaching about to the center, has been hollowed out on the ventral side. Diameter 0.10-0.17 m.m. It is composed largely of muscle fibres, radiating from the center of the opening. The shape of the sucker, of course, changes greatly with the state of contraction. There is a single layer of circular muscle fibres around the rim of the sucker, extending for a very short distance inside and about one-third the height on the side imbedded in the parenchyma. The whole organ is bounded sharply by a membrane on this side. Several bundles of muscle fibres run thru the body parenchyma from the ventral sucker to the dorsal surface. (Pl.II, Fig.2)

The oral sucker is a similar spherical mass of radially arranged muscle fibres, a trifle smaller, however, diameter 0.09-.15m.m. at the extreme anterior end of the body, opening ventrally. The opening is trumpet shaped and nearer the ventral side than the dorsal. (Pl.II,Fig. 3)

The body wall is composed of a noncellular cuticula,several layers of muscle fibres and a region of closely packed cells merging with the parenchyma. The cuticula is a thin layer dotted with minute pits some 3 apart. These contain a dark or heavily staining substance, perhaps rudimentary spines. Adjacent to the cuticula is a layer of very fine close-lying circular muscle fibres, a little over 1 apart. Next is a layer of coarse longitudinal fibres and two layers of coarse oblique fibres making angles of 60° with each other and with the longitudinal; the three thus forming a pattern of equilateral triangles. The fibres in these layers are at varying distances apart, depending on the part of the body examined. They are most abundant in the anterior ventral region. Next are layers of cells with heavily staining nuclii. These merge into the parenchyma that loosely fills the spaces of the body not occupied by organs. There are numerous unicellular glands especially in the anterior part of the body. (Pl.IX, Fig. 29).

The digestive tract is very short and simple. The mouth is in the anterior sucker. There is a short prepharynx some 80 long. Following and projecting into a slight enlargement of the prepharynx is the pharynx, an elliptical organ some 50 long x 35 in diameter, perforated by a narrow lumen. It is composed

largely of radially arranged muscle fibres. There is, in addition, a single layer of circular fibres on the inside and anteriorly on the outside. The oesophagus extends to about the end of the first third of the body. It is a straight narrow tube lined by a noncellular cuticula as are the preceding parts, and with a single layer of coarse, longitudinal muscle fibres some two dozen in number, outside the cuticula. These are likewise to be found around the prepharynx. (Pl.II, Fig. 4 and 5) The oesophagus divides into a right and a left intestinal branch diverging at about 120° from each other, very short, .09-.18m.m. in length, tho of large cross section. These are not lined by cuticula but by an epithelium of large cuboidal cells. (Pl. II, Fig. 6)

Excretory System

The excretory system consists of sixteen large flame cells, a system of forking canals, a large bilobed vesicle and a short ciliated canal to the exterior. All parts were easy to follow in sections. The details were obtained by reconstructing the system in four series of transverse sections. The reconstructions were made by measurements with the ocular micrometer plotted on a previously reconstructed lateral or dorsal view of the animal. These have all checked with each other. The number and position of the flame cells was checked in several other series.

The excretory pore is at nearly the extreme posterior end of the body. As a rule it is dorsally placed and slightly in front of the extreme end. It is at the end of a short, thickly ciliated canal. This canal is the outlet of a vesicle which extends

forward for one-third to two-fifths of the length of the body. Almost from the first the vesicle shows median longitudinal constrictions on the dorsal and ventral surfaces, and at one-third to one-half its length it divides completely into right and left lobes. These are more or less cylindrical, tapering somewhat at the anterior end. The whole vesicle lies fairly close to the dorsal surface of the body. The lining of the excretory vesicle and its outlet are crowded with nuclii but muscle fibres were not detected. (Pl. IX, Fig. 32)

The system of canals and flame cells is bilaterally symmetrical - eight flame cells on each side of the body. There is also a certain biradial symmetry. As mentioned above, the vesicle lies along the dorsal surface of the body. From the anterior end of each lobe a canal drops to the ventral surface and divides into a posterior and an anterior branch. Four flame cells supply the anterior branch and four supply the posterior and with exactly corresponding canals. In fact, all of the flame cells are similarly placed with respect to canals - all have just three forks between them and the vesicle. In each of the pairs of flame cells which are immediately connected by a fork, one is decidedly dorsal, the other ventral.

Taking the system in more detail, we find that the perpendicular canal from the vesicle divides in a region posterior and to the side of the ventral sucker. The anterior branch was considerably closer to the ventral surface than the dorsal and about half way between the edge of the body and a median plane. It forks in the region of the intestinal branches into a short dorsal

and a longer anterior branch. The dorsal divides very soon into a dorsal and a ventral canal, each of which terminating in a flame cell. The dorsal flame cells are near the midline of the body, while the ventral are usually near the edges. The anterior branch continues the course of its parent canal and forks in the region of the pharynx. The dorsal fork runs posteriorly and toward the mid plane before ending in a flame cell; the ventral runs anteriorly and toward the midplane bringing its terminal flame cell close to the side of the anterior sucker.

Going back to the posterior branch of the perpendicular canal, we find that it runs for a short distance in a diagonal direction, posteriorly and laterally before dividing into a posterior and an anterior branch. The anterior divides soon into dorsal and ventral flame-cell-bearing canals. The dorsal flame cell is almost always to be found closely pressed against the anterior end or outer face of the testes on that side of the body. The ventral flame cell is usually not far from the side of the ventral sucker. The posterior branch runs out to the extreme margin of the body then sharply toward the dorsal surface, all the time between the folds of the uterus and the body wall. It divides into an anterior dorsal and a posterior ventral flame-cell-bearing canal. The anterior flame cells were found in all cases closely pressed to the posterior ends of the testes. The posterior were pressed back by the last folds of the uterus. (Pl. III, Fig. 7; Pl. IV, Fig. 8)

This is the typical condition but there is some variability in the directions of some of the canals and the position of their

flame cells. The number of flame cells - sixteen - is constant. The number of canals was constant with the exception of one specimen in which the short dorsal canal in the region of the intestinal branches was suppressed. The first ventral pair of flame cells are always in the region of the anterior sucker - often closely pressed to it. The first dorsal pair attend to the pharyngeal region of the parenchyma. Some of the second ventrals or second dorsals are often found closely pressed to the seminal vesicle or ovary, but this seems to be a rather accidental relation - due to excessive development of these organs. They can only be said to take care of the region of the intestinal branches. With the exception of one side of one specimen the third ventrals were found fairly close to the ventral sucker. This same specimen furnished the only case in which the third dorsals were not both closely pressed to the anterior end of the testes. In this specimen the canal of the third pair of flame cells on the left side extended very far forward, bringing the flame cells opposite the second pair on the right side. The fourth dorsal pair were found close to the posterior end of the testes in all cases. The fourth ventrals simply took care of the posterior end of the body. No flame cellswere ever found between folds of the uterus and the only canal in the system that passes among folds of the uterus is the perpendicular one leading downward from the vesicle. The canals of the fourth pair of flame cells were often so compressed between the uterus and the body wall that it was difficult to trace them.

These flame cells are very favorable for study. They are very large and of typical form - a cell with a conspicuous nucleus cytoplasmic processes spreading out and a conical bunch of cilia some 15 μ long which project into the end of a canal. The canals seem to have a very firm lining but no nuclei. (Pl.IX, Figs.33 and 34).

The great simplicity of the excretory system in this form may be merely correlated with its small size and due to degeneration, but it seems not unlikely that it may represent quite a primitive condition. In the fact that the main trunks divide in the middle of the body into anterior and posterior branches, it is a good representative of Looss'typical form for distomes from which, in "Die Distomen unsere Fische und Frosche", he derives such apparently diverse forms as that in which the main trunks go to the anterior end of the body and return on themselves or even the complex network of Fasciola hepatica. Perhaps the forks in these anterior and posterior branches are also significant since they appear in otherwise widely different forms - for example Distomum heterophyes as described by Looss 1894 in which the forking is just the same as in microphallus opacus except that the flame cells are in bundles of threes instead of twos, making twenty-four in all, instead of sixteen. Perhaps this very symmetrical arrangement indicates descent from a biradial form about as broad as long.

Female Reproductive System

The ovary is a large ellipsoidal organ on the right side of the middle region of the body, paired in away with the seminal vesicle but farther back and more dorsal than the latter. It is packed with the heavily staining polygonal ova - cells some 11μ in diameter. No structure was made out in its walls. Pl. V, Fig. 11, Pl. VIII, Fig. 15)

The oviduct leaves at the posterior left part of the ovary as a narrow tube some 10μ in diameter with a firm apparently ciliated wall. Near the median plane of the body it is joined by Laurer's canal, a somewhat narrower tube which bends to the left and posteriorly before turning to its opening on the dorsal surface left of the mid line. Immediately after the junction with Laurer's canal, the oviduct arches dorsally. (Pl. VI, Fig.15) At the beginning of the arch it receives the united "vitelline" duct. Some 20μ beyond is the entrance of the "Shell glands" which are a mass of large flask shaped cells, staining heavily, whose narrow ducts enter the uterus in one small region. (Pl.VIII, Figs.21, 22, 23, 24). The glands fill most of the region between the front half of the testes. Between the entrance of the "vitelline" duct and of the "shell" glands the wall of the oviduct is crowded with large nuclei. Muscle fibres were not distinguished, but this seemed the most likely place for the shaping of the eggs, being just the right size. The arch of the oviduct - now the uterus continues downward to the middle of the body and enlarges greatly. This enlarged portion makes a series of complicated folds filling all unoccupied space in the posterior half of older ani-

mals and finally ends in a muscular tube, the metraterm, which leaves the body at the genital pore. There is no receptaculum seminer in the system.

The "vitelline" duct proceeds down from the arch of the oviduct and very shortly divides into right and left branches. These turn posteriorly and expand in their course like trumpets. The condition of the glands is very different in young and old animals. In fact all of the reproductive organs suffer great changes in size. In young specimens the ducts end in large masses occupying most of the sides of the posterior half. Each is composed of a number of large spherical lobes, some fused side by side and some connected by small ducts in an irregular way. In these specimens the uterus is a narrow tube winding around in the parenchyma between the two "yolk" glands; the ovary and testes are large and round often over one-half the thickness of a cross section, while the seminal vesicle may be rather small, often smaller than the ovary. On the other hand in older specimens, the "yolk" glands lose their spherical lobes and become irregular masses compressed into the mould of the uterus folds which here fill the hind body so completely that almost no parenchyma is to be seen. (Pl. V., Figs. 13 and 14) In some cases nothing can be found of the "vitelline" glands but the stumps of their ducts and perhaps a few scattered "yolk" cells. Here the testes are smaller and compressed into an irregular shape, the ovary is smaller and the seminal vesicle becomes larger than the ovary, sometimes swollen to reach almost from the dorsal to the ventral surface. The "yolk" cells are cells a little smaller than the ova

which are largely composed of a brown shell material arranged in droplets in a sphere at one pole of which is a nucleus. (Pl. VIII, Fig. 27).

The folds of the uterus at first sight appear very complex but they are in reality quite simple and constant. I followed the convolutions carefully in nine series. Seven followed the plan below perfectly, the others differed more or less. The method of study was the reconstruction of sections transverse in eight cases, frontal in the other. The frontal was reconstructed directly by camera drawings of the successive sections. The sections of the transverse series were first rapidly sketched and the foldings of the uterus followed and numbered in the sketches. Then the folds were located by measurements with the ocular micrometer and put in a previously reconstructed ventral view. This second method was much the quickest and was accurate enough.

The general plan is this: The enlarged portion begins in the center of a cross section in the middle region of the body, proceeds posteriorly, enlarging all the time, finally loops forward on the right side ventral to the "yolk" glands, reaching its starting point. Then it forms the same folds on the left side in reverse order and the final portion becomes small again, goes forward side by side with the first portion and when the latter rises toward the "shell" glands, the former drops to leave the body at the genital pore. The ventral circuit on both sides is typically quadrilateral in shape tho there are often many additional small twists in it. The lateral and anterior sides of this are

the most enlarged portions of the uterus. Sometimes they will have a diameter one-fourth that of the body. The dorsal circuit is typically triangular, in fact almost invariably has but two folds. (Pl. VII, Fig. 17 and 18)

Shortly after the point where the uterus turns downward at the end there is a sudden constriction surrounded by powerful circular muscle fibres. This marks the beginning of the metraterm. Beyond it expands somewhat but continues to be surrounded by circular muscle fibres tho by finer ones than those at the constriction. There are numerous nuclii outside the fibres. It opens in the upper part of the genital atrium to the left of the male papilla, that is, on the side farthest from the ventral sucker. (Pl. VIII, Fig. 19).

Male Reproductive System

The testes are two large ellipsoidal organs, paired with each other, a little back of the middle of the body, and just beneath the dorsal wall. The right testis is immediately back of the ovary. They are packed with spermatozoa and cells undergoing metamorphosis into spermatozoa. The structure of the walls could not be made out. The vasadeferentia are irregular tubes leaving the testes at the anterior end and joining some distance forward. The united duct leads very shortly into the upper posterior part of the enormous seminal vesicle. (Pl. V. Fig. 11) There is a rather curious relation in that the vas deferens on the right side passes behind and over the vitelline duct on that side while the left vas deferens passes in front and over the left vitelline duct. It may be mentioned here that the uterus passes anterior to the vitelline duct but posterior to the vasa deferentia. The vitelline ducts are usually distorted somewhat from bilateral symmetry by the interweaving, but the vasa deferentia are distorted more. (Pl. VI, Fig. 15 and 16)

The seminal vesicle is a large ellipsoidal organ on the left side of the body, about the size of the ovary and a little anterior and lower down than the latter. It is usually found packed with spiral masses spermatozoa. The walls were without structure as far as could be seen. It has a large outlet at the lower posterior part which runs downward to the left of the ventral sucker. There are numerous one-celled prostrate glands around the upper part of this canal. The last third of the ductus ejaculatorius is the lumen of a protrusible organ the copulatory papilla, which is ordi-

narily held within the body in a pouch of the body wall, the genital atrium. Heavy muscle fibres connect the papilla at its base with the body wall around the opening of the genital atrium, enabling the papilla to be protruded. The wall of the papilla itself is composed of radially arranged muscle fibres. (Pl. VIII, Fig. 20) As mentioned before the opening of the metraterm is at the upper part of the atrium just left of the papilla.

Eggs

The eggs are ellipsoidal some 25-30μ x 13-17μ. They have a yellowish brown color. There is a cover at one end. (Pl. VIII, Fig. 28) They appear to be formed in the uterus between the "vitelline" duct and "shell" gland by the coming together of an ovum, a sperm cell and several shell cells from the "vitelline" gland. Spermatozoa can be seen in large quantities entering the end of the metraterm in all parts of the uterus, in the oviduct and in Laurer's canal. The last is apparently an escape for superfluous sperm. "Eggs" appear to be formed, frequently, wholly of shell material. Very often the shell material does not seem to be fluid enough when given up by the shell cells and great numbers of unenclosed ova, ova adhering to irregular shell masses, and great masses of half-fused shell material can be found in the uterus. (Pl. VIII, Fig. 26).

Specimen with Two Ovaries.

One very remarkable specimen was examined. Aside from minor peculiarities, it was distinguished by having two ovaries.

This specimen was the shortest in proportion to its breadth and thickness of any examined. The dimensions were 1.0 x 0.7 x 0.55 m.m. The anterior sucker and digestive trace seemed normal except that the branches of the intestine were unusually short and spread out at right angles to the oesophagus, being closely pressed against the seminal vesicle. The ventral sucker was extremely far back. The opening was at the beginning of the last third of the body. Its breadth was about normal but it was unusually low and very long. Its very deep cavity was turned posteriorly. The seminal vesicle was centrally placed and globular. The ductus ejaculatorius instead of dropping straight down went almost directly posteriorly and with the metraterm left the body at an extremely oblique angle. The opening was however left of the opening of the ventral sucker. Transverse sections of the animal usually nearly split the ductus; here the cross section was almost circular.

The two ovaries were exactly paired with each other - right and left. Both were dorsal to the seminal vesicle. Both were ellipsoidal and closely followed by a normal testis. The left ovary, the abnormal one, was considerably the larger. It had no outlet. The outlet of the right was normal tho considerably displaced in parts. The oviduct went upward, arched to the left and then dropped straight downward at the uterus to the middle of the

middle of the body. Laurer's canal left the arch and proceeded nearly straight upwards - a little posteriorly but very slightly to the left as it would normally. The "vitelline" duct left the oviduct beyond Laurer's canal on the posterior side, dropped downward and divided into right and left halves. The vasa deferentia passed back of the right and in front of the left "vitelline" duct as is normal. If an oviduct had left the left ovary and arched around to the base of Laurer's canal the system would have been quite bilaterally symmetrical. The folds of the uterus were not traced thruout owing to imperfections in the series, but seemed wholly normal. The excretory vesicles were normal.
(Pl. VI, Fig. 16)

Nervous System

The larger nerves show fairly well on slides stained with haematoxylin as gray bundles of fibres in a blue background. The smaller nerves I frequently had trouble in following from section to section. Only the larger nerves could be followed in transverse sections. Sections tangential to the dorsal, ventral and marginal sides, gave the best results. There was no one series in which the entire system could be followed, but each nerve was checked in several series with the exception of the circular commissures, the number of which between the central nerve mass and the ventral sucker could not be decided with certainty. The figure is based on a reconstruction of the most favorable series and shows the greatest number of commissures found. It is, of course, diagramatic for clearness. (Pl.X, Fig. 35)

The central part of the nervous system is a large mass forming an arch over the prepharynx just in front of the pharynx. Radiating from the right and left ends are nerve bundles connecting with the eight great longitudinal trunks and ones supplying the oral sucker. Considering only one side, there are six nerves given off, four in a more or less horizontal plane, one directly upwards and one downwards. The largest one runs posteriorly from the central mass and outwards at an angle of about 30°. Near the end of the first third of the body it drops down to the ventral surface and continues back along this surface curving inward somewhat in the region of the ventral sucker. This is the main trunk. The next nerve in order in the horizontal plane is

a very fine one, at right angles to the long axis of the body and connecting with the lateral trunk. Next is a large bundle going forward and out some 45° and dividing into a short branch running forward to the sides of the oral sucker and the large lateral trunk which runs far back along the lateral margin of the body. A large but short branch runs directly forward and slightly dorsally over the dorsal surface of the oral sucker. (Pl. IV, Fig.31) The ventral bundle runs also outwards and forward and is connected at the ventral surface with the corresponding nerve on the other side by a commissure. Two small nerves run forward from the point of connection and a fairly large ventral, longitudinal trunk runs backward one-fourth to one-third the length of the body. It stops just where the main trunk reaches the ventral surface. The dorsal bundle from the central mass divides at the dorsal surface, the forward branch running to the anterior end of the body, curving down with the curve of the body and ending just above the oral sucker while the backward branch is the dorsal longitudinal trunk and runs back parallel to the long axis of the animal. A short distance back of the central mass the main trunk sends out large bundles to the ventral, lateral and dorsal trunks. (Pl. IV, Fig. 30) The dorsal, lateral and ventral, or in the posterior part of the body, the main trunks are connected by commissures. In my preparations these could only be determined satisfactorily between the ventrals and between the dorsals and in these the number could not be determined certainly. Four was the greatest number observed on the ventral surface between pharynx and ventral

surface between pharynx and ventral sucker. Some of these were double. Another showed three very plainly, while others were doubtful. The commissures connecting with lateral trunk were only seen beginning and could not be stated to be complete commissures from my preparations.

The main trunk sends a couple of branches from each side to the ventral sucker. These seem to run directly into the circular muscles around the base of the sucker. The system in the posterior part of the body could not be determined at all.

This arrangement of the nervous system agrees in most respects with those that I have found described. I have not, however found reference to the ventral longitudinal trunk. The main trunk which reaches the ventral surface where the ventral ends is the one usually called the ventral. As the ventral trunk is immediately below the main trunk, close to it, and smaller, it would properly be difficult to distinguish in whole mounts. The great development of the nervous system - eight longitudinal trunks radiating from a central ganglion seems rather remarkable in a parasite. The constancy thruout the trematodes indicates that it is a very primitive condition. It certainly can not be derived from the nervous system of other plathelminthes, altho these might be derived from it. Perhaps it may go back to a biradial form with a ganglion at the upper pole and eight radiating nerves corresponding to the eight branches of the excretory system.

In conclusion, I wish to express my gratitude to Professor Henry B. Ward for the material and for the aid and encouragement which he has given me in this work.

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Description of Plates

Plate I.

Fig. 1. Dorsal view of specimen preserved in corrosive sublimate, stained in paracarmine and mounted in balsam. x82.

Plate II.

Fig. 2. Sagittal section thru ventral sucker. x330

Fig. 3. Saggital section thru oral sucker. X330

Fig. 4. Frontal section thru pharynx and adjacent parts of prepharynx and oesophagus, showing musculature. x730.

Fig. 5. Transverse section thru oesophagus, showing longitudinal muscles. x730.

Fig. 6. Transverse section thru an intestinal branch, showing character of epithelium. x730.

Plate III.

Fig. 7. Dorsal view of excretory system, reconstructed by measurements from transverse sections.

Plate IV.

Fig. 8. Excretory system of left side, from side view reconstructed from same series as Fig. 7. Somewhat foreshortened.

Plate V.

Fig. 9. Transverse section thru oral sucker. x100.

Fig.10. Same series as Fig. 9 thru prepharynx, showing central nerve mass and a fork of the excretory system. x100.

Fig. 11. Same series as Fig. 9, thru ovary and seminal vesicle showing in addition, oviduct, vasa deferentia, "shell" gland, etc. x100.

Fig. 12. Same series as Fig. 9, thus oral sucker, showing testes, folds of uterus, genital atrium, etc. x100.

Fig. 13. Same series as Fig. 9., thru posterior part of body, showing lobes of excretory vesicle, folds of uterus and compressed yolk glands. x100.

Fig. 14. Transverse section similar to that of Fig. 13, in another series, showing largely developed yolk glands and small uterus. x100.

Plate VI.

Fig. 15. Reconstruction from several transverse sections, showing typical arrangement of reproductive organs (except middle of uterus) from posterior end.

Fig. 16. Similar reconstruction to Fig. 15, made in a specimen with two ovaries.

PlateVII.

Fig. 17. Ventral view of the folds of the uterus, reconstructed by measurements from transverse section.

Fig. 18. Similar view to Fig. 17, showing a younger stage.

Plate VIII.

Fig. 19. Metraterm showing coarse and fine circular muscles. x730.

Fig. 20. Copulatory papilla showing the protruded condition and the muscles which effect the protrusion. x730.

Fig. 21. Oviduct, entrance of "yolk" glands and "shell" glands, etc., from a transverse section. .730.

Fig. 22. "Shell" gland cells. .730

Fig. 23. Cross-section of nucleated region before entrance of "shell" glands, from a frontal section. z730.

Fig. 24. Next section to that of Fig. 23 in the series, showing entrance of "shell" glands.

Fig. 25. Ova. x730.

Fig. 26. A malformed egg, showing an ovum and several "yolk" cells. x730.

Fig. 27. Yolk cells. x730.

Fig. 28. Eggs. Two showing mitosis. x730.

Plate IX.

Fig. 29. Tangential section to ventral surface, just anterior to ventral sucker, showing musculature, etc. x730.

Fig. 30. Transverse section showing the eight longitudinal never trunks and two commissures. x170.

Fig. 31. Frontal section, slightly skew, showing the branches of the central nerve mass at one side. x170.

Fig. 32. Posterior end of excretory vesicle showing ciliated canal to exterior. x330.

Fig. 33. Flame cell. x730.

Fig. 34. Flame cell. x730.

Plate X.

Fig. 35. Dorsal view of nervous system. Diagramatic.

Explanation of Drawings.

Abbreviations.

C G	Central Ganglion.
C M	Circular Muscles.
D E	Ductus ejaculatorius.
D L N	Dorsal longitudinal nerve.
E C	Excretory canal.
E V	Excretory vesicle.
F C	Flame cell.
Int	Intestinal branch.
L C	Laurers canal.
L L N	Lateral longitudinal nerve.
L M	Longitudinal muscle fibres.
M	Metraterm.
M L N	Main longitudinal nerve.
N	Nucleus.
Oes	Oesophagus.
O S	Oral sucker
Ov	Ovary.
Od	Oviduct.
Pap	Capulatory papilla.
Phar	Pharynx.
P M	Parenchymal muscle fibres.
Pr	Prostate glands.
Pre	Prepharynx.
R M	Radial muscle fibres.
S G	"Shell" gland.
T	Testis.
Ut	Uterus.
V S	Ventral sucker.
V Sem	Vesiculum seminalis.
Y D	"Yolk" duct.
Y G	"Yolk"gland.

Microphallus opacus

Plate I.

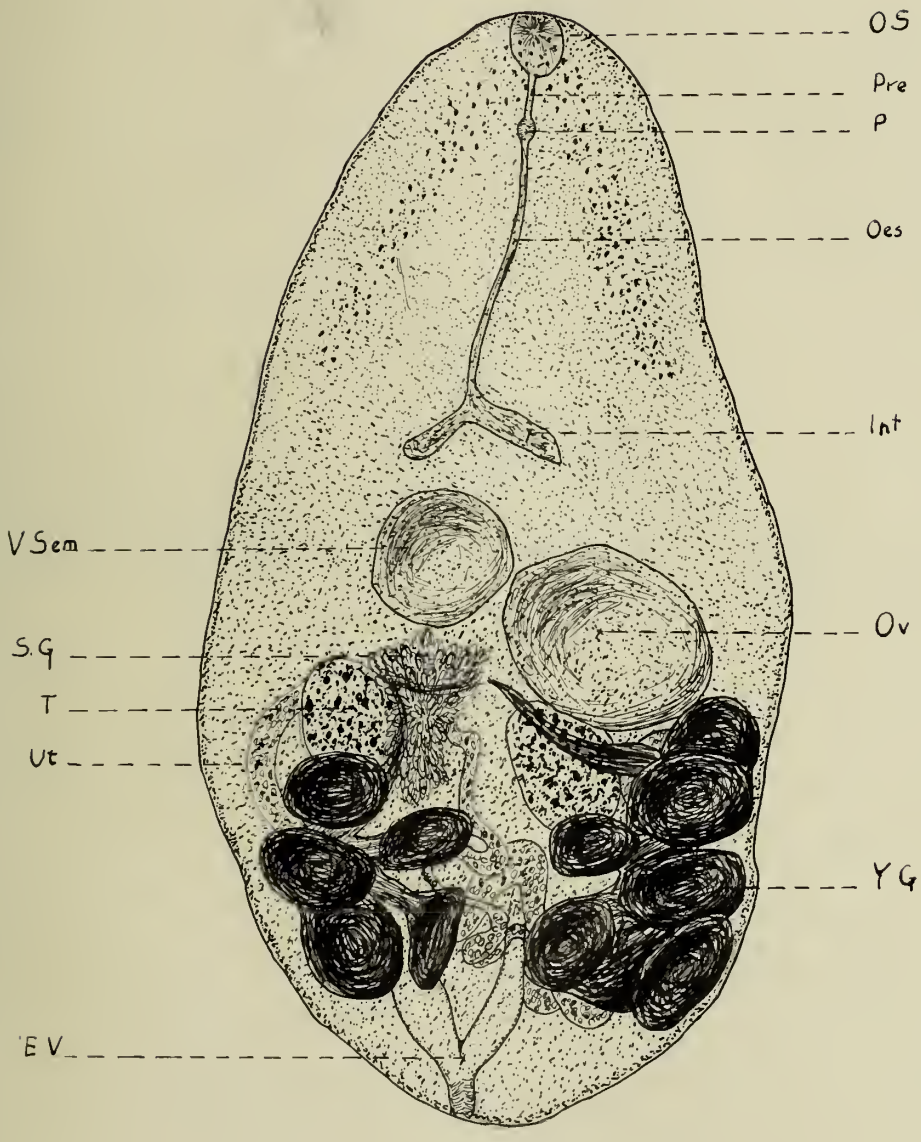

Fig. 1
Dorsal View
x82

Details of Suckers and Digestive System

Plate II.

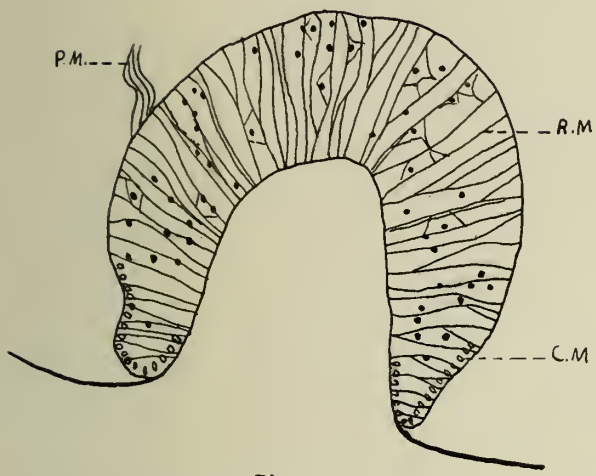

Fig. 2
Ventral Sucker, Sagittal
x330

Fig. 3
Oral Sucker, Sagittal
x 330

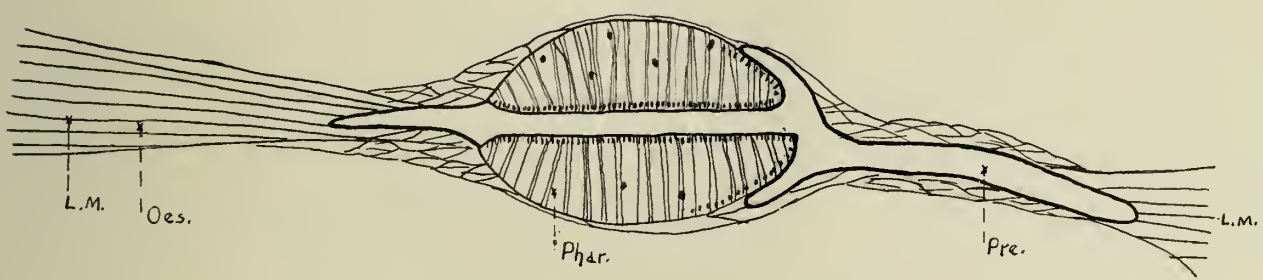

Fig. 4
Pharyngeal Region of Digestive Tract
x 730

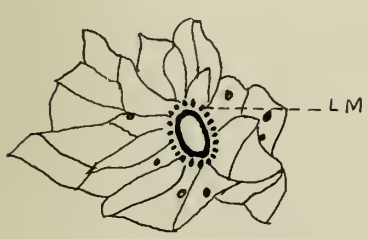

Fig 5
Oesophagus, transverse
x730

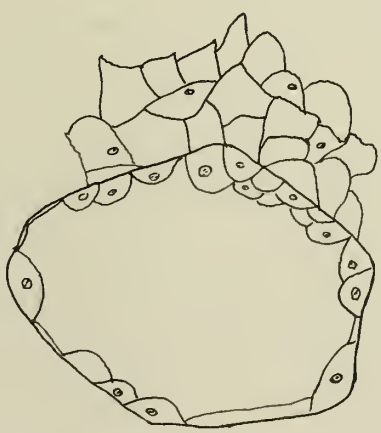

Fig. 6
Intestinal Branch
Transverse
x 730

Excretory System

Plate III.

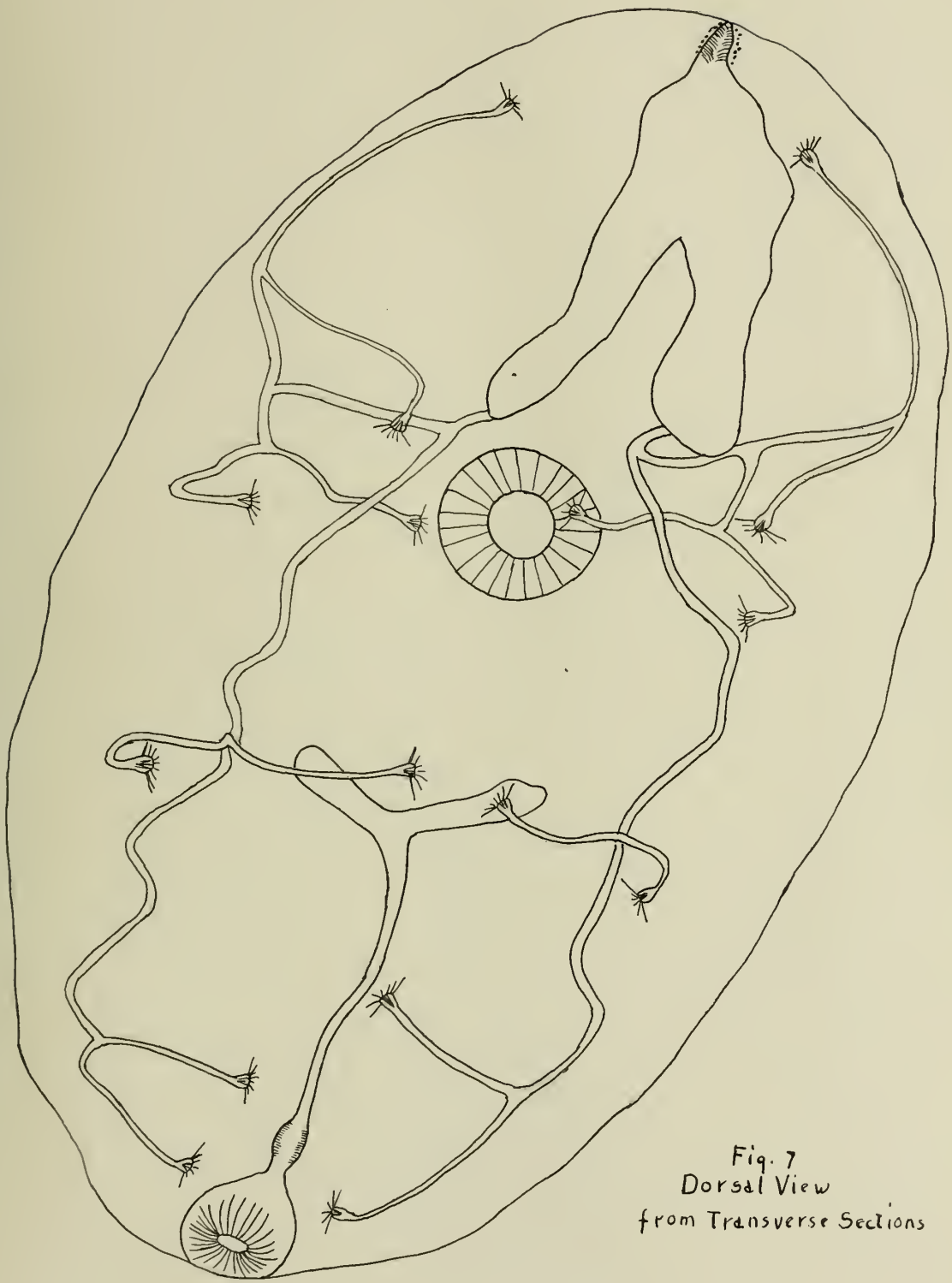

Fig. 7
Dorsal View
from Transverse Sections

Excretory System
Plate IV.

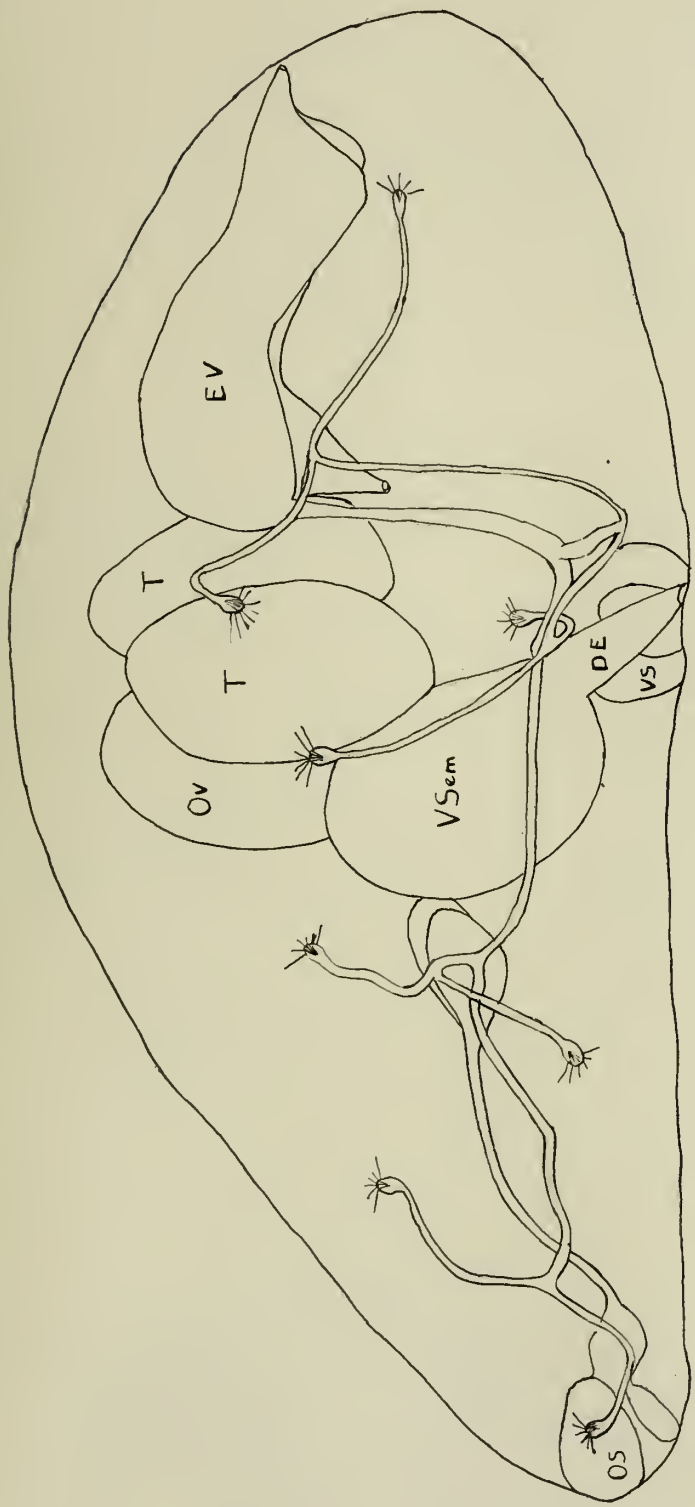

Fig. 8
Left Side, Somewhat Foreshortened
Same Series as Fig. 7

Transverse Sections
Plate V.

Fig. 9

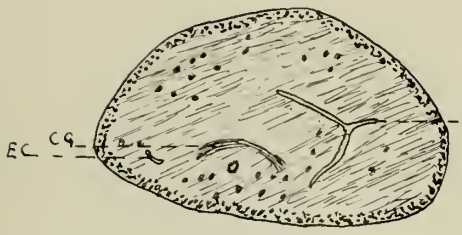

Fig. 10

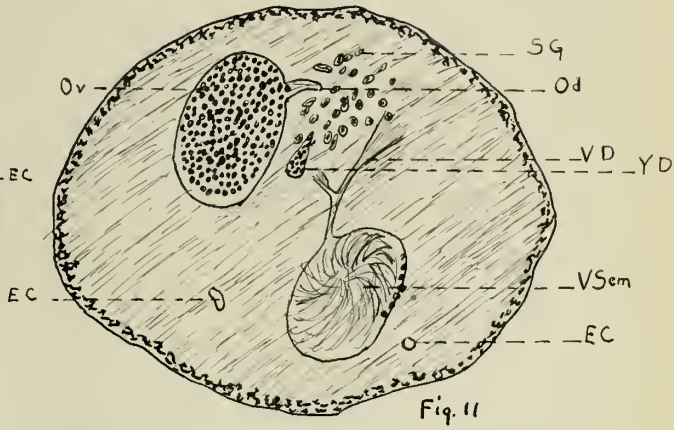

Fig. 11

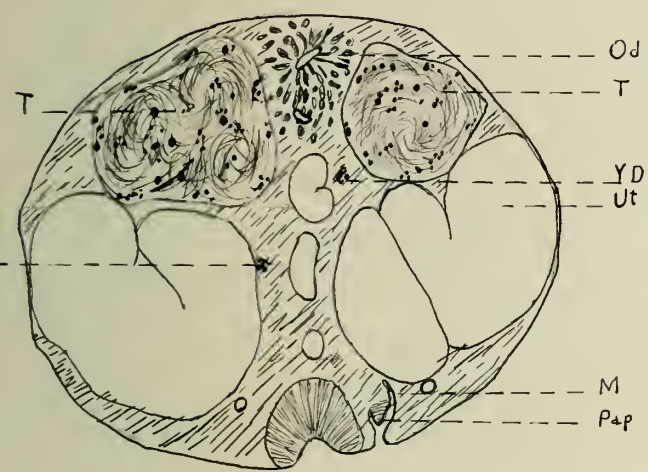

Fig. 12

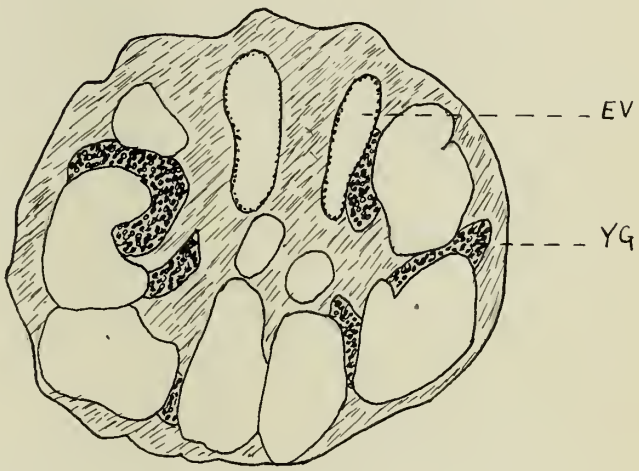

Fig. 13

Characteristic Sections of a Series
x 100

Fig. 14

Section for Comparison with Fig. 13
x 100

Reproductive System
Plate VI.

Fig. 15
Normal Specimen
view from posterior end

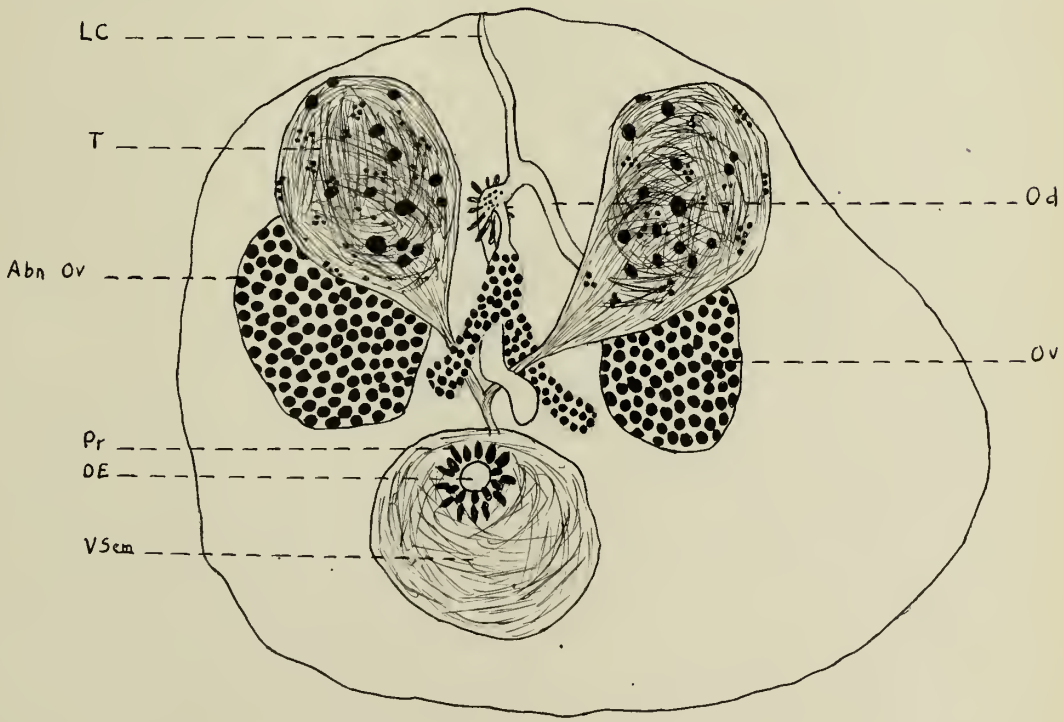

Fig. 16
Specimen with two Ovaries
view from posterior end

Folds of the Uterus
from Transverse Sections
Plate VII.

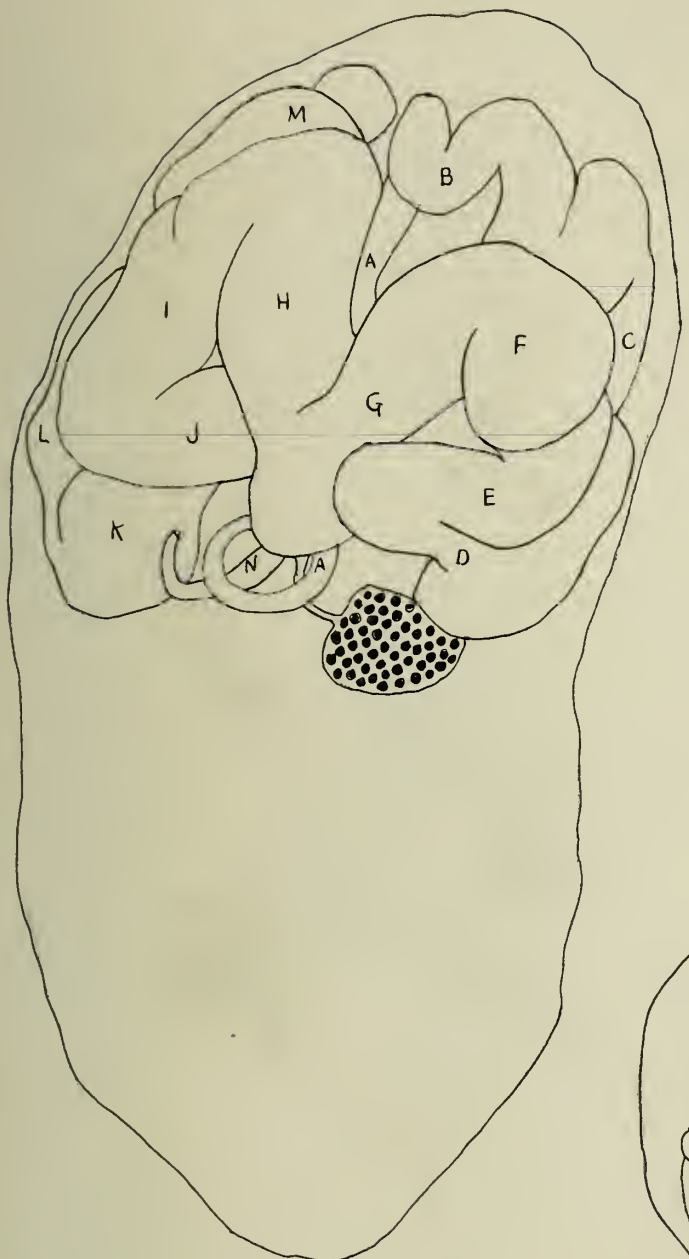

Fig. 17
Reconstructed from Transverse
Sections by Measurement
Ventral View

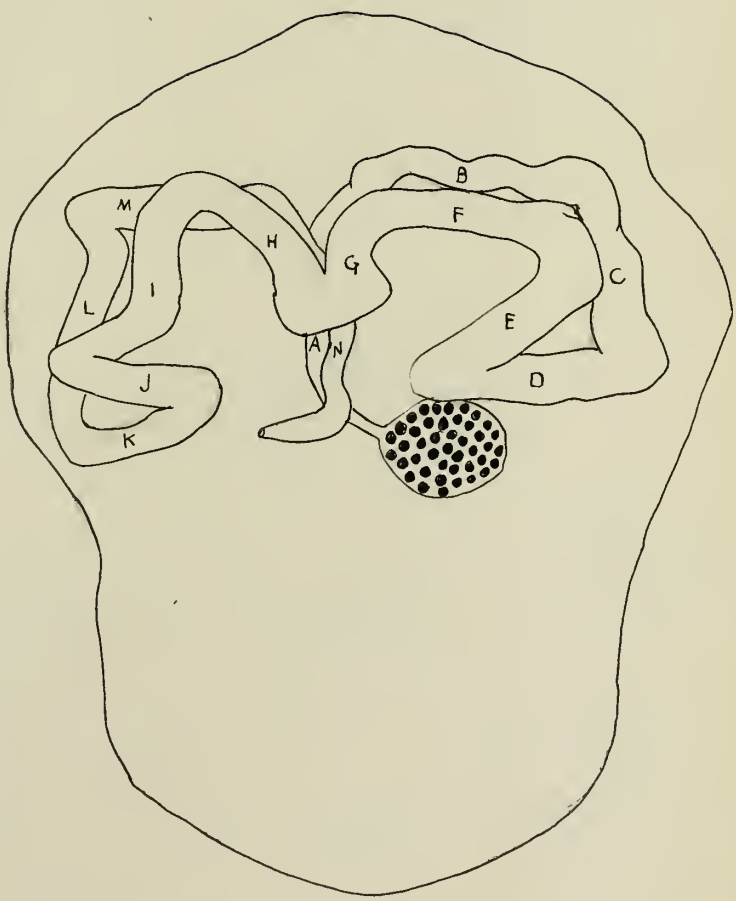

Fig. 18
Younger Stage than Fig. 17
Constructed Similarly
Ventral View

Details of Reproductive System

Plate VIII.

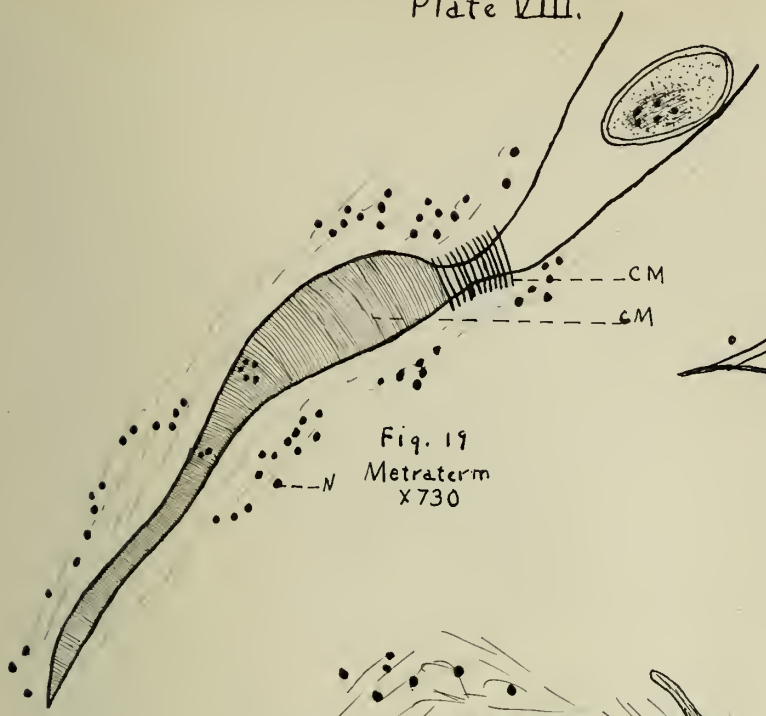

Fig. 19
Metraterm
x 730

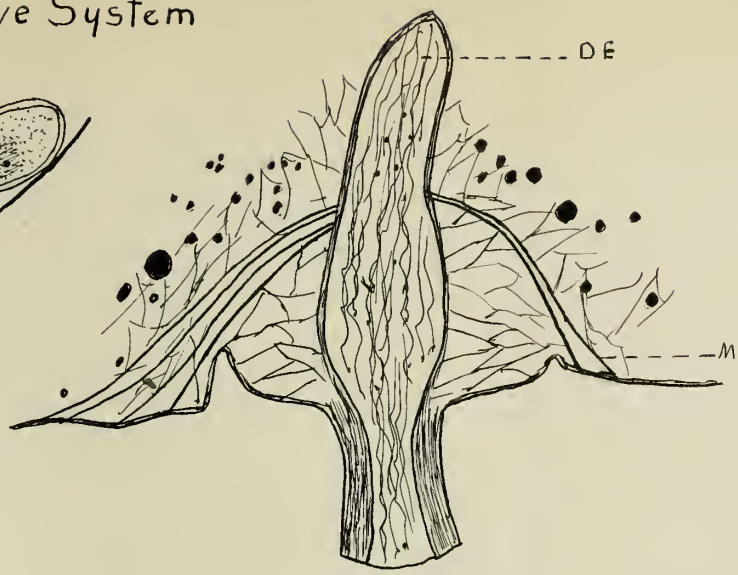

Fig. 20
Copulatory Papilla
protruded
x 730

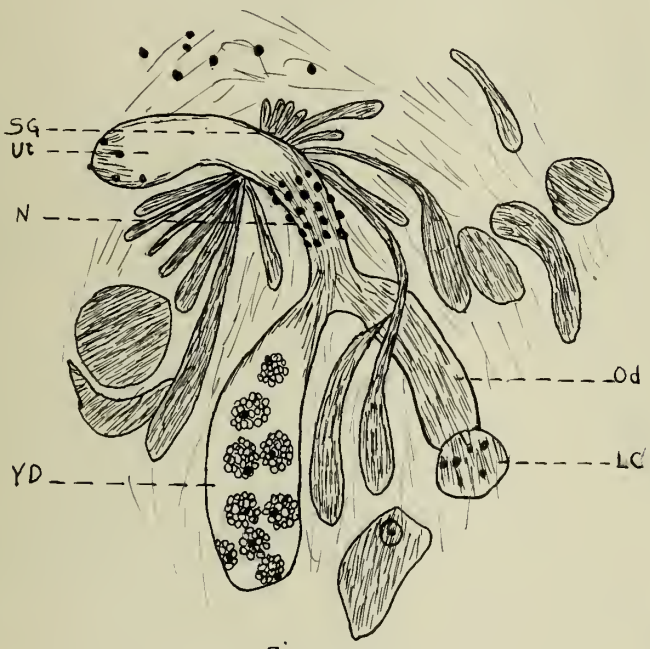

Fig. 21
Entrance of "Shell" Gland
x 730

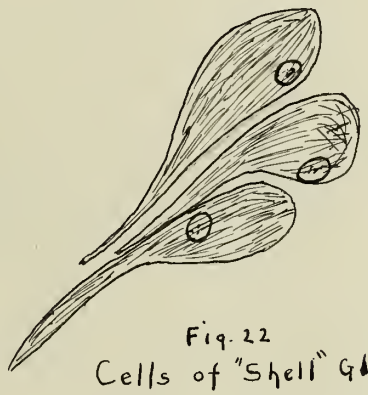

Fig. 22
Cells of "Shell" Gland
x 730

Fig. 25 Ova
x 730

Fig. 27 "Yolk" cells
x 730

Fig. 26 Malformed
Egg. x 730

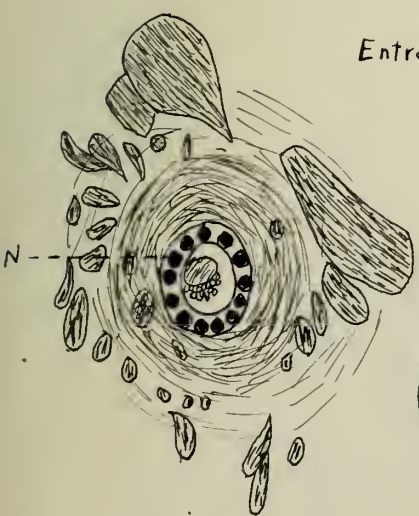

Fig. 23

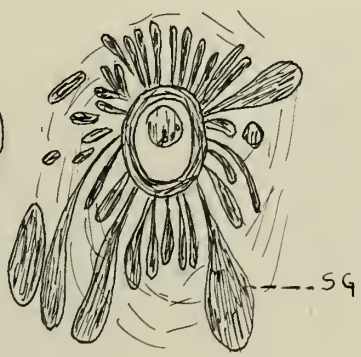

Fig. 24

Successive Cross-sections thru Region
of Entrance of "Shell" Glands
x 730

Fig. 28 Eggs
x 730

Details of Integument and of Nervous and Excretory Systems

Plate IX.

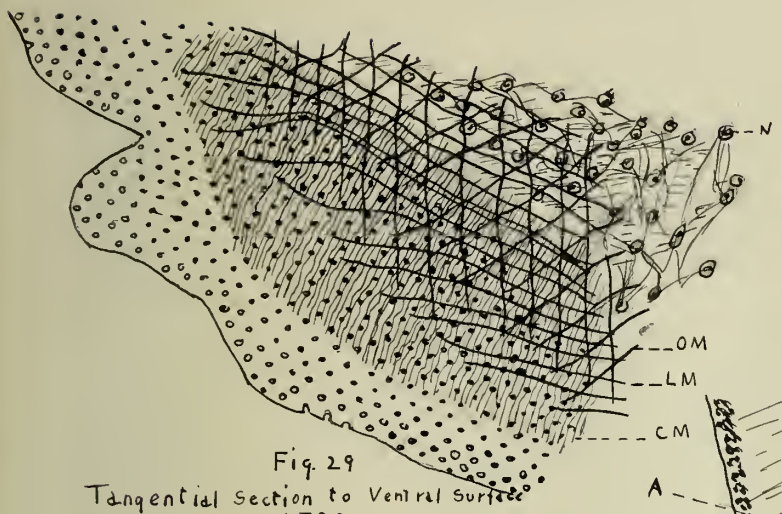

Fig. 29
Tangential Section to Ventral Surface
X 730

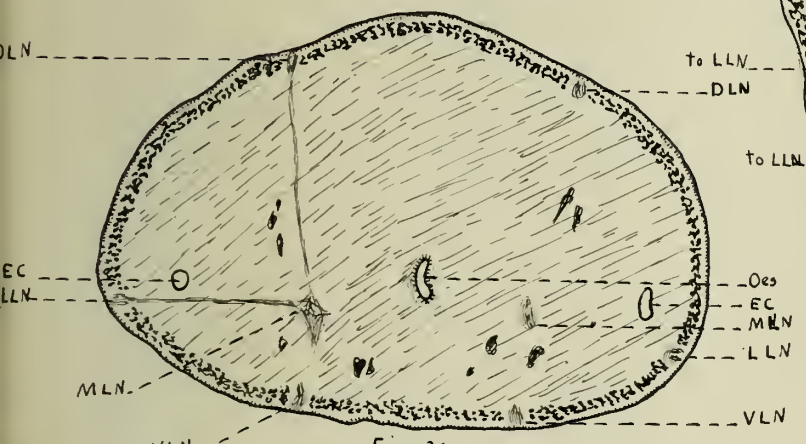

Fig. 30
The Longitudinal Nerve Trunks
Transverse Section as A-B Fig. 31
X 170

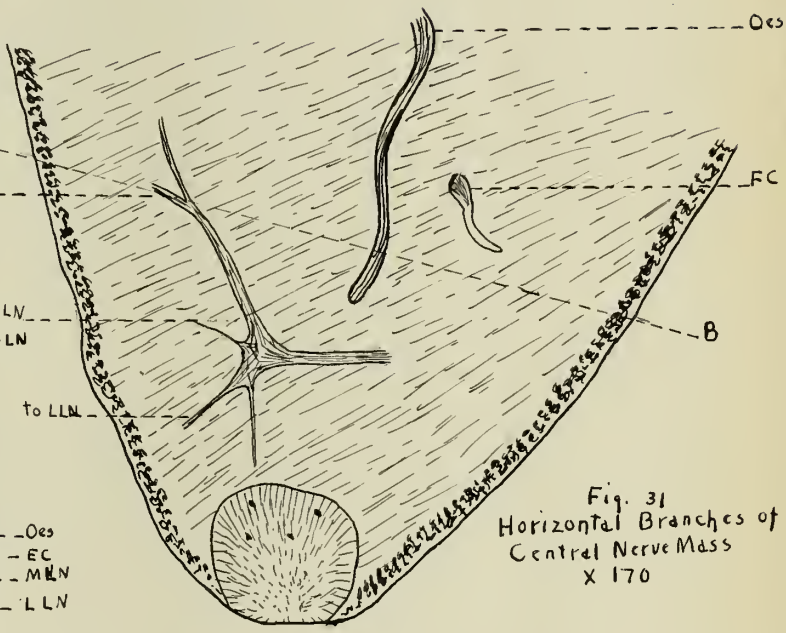

Fig. 31
Horizontal Branches of Central Nerve Mass
X 170

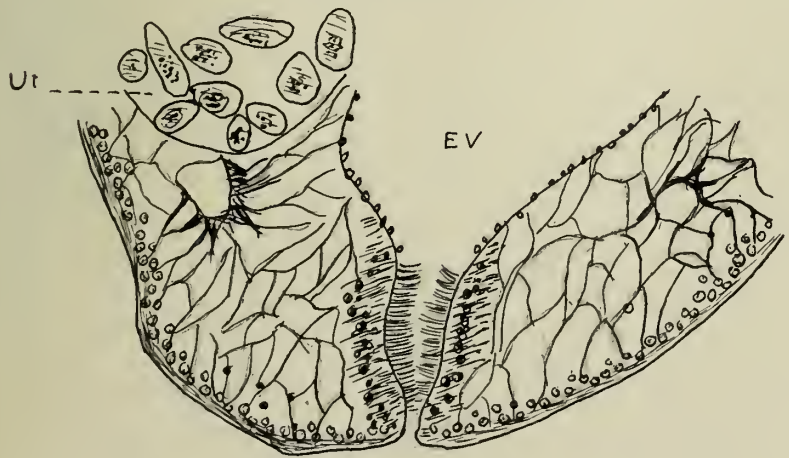

Fig. 32
Excretory Pore etc.
X 330

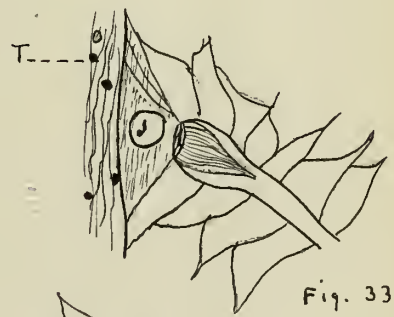

Fig. 33

Flame Cells
X 730

Fig. 34

Nervous System

Plate X

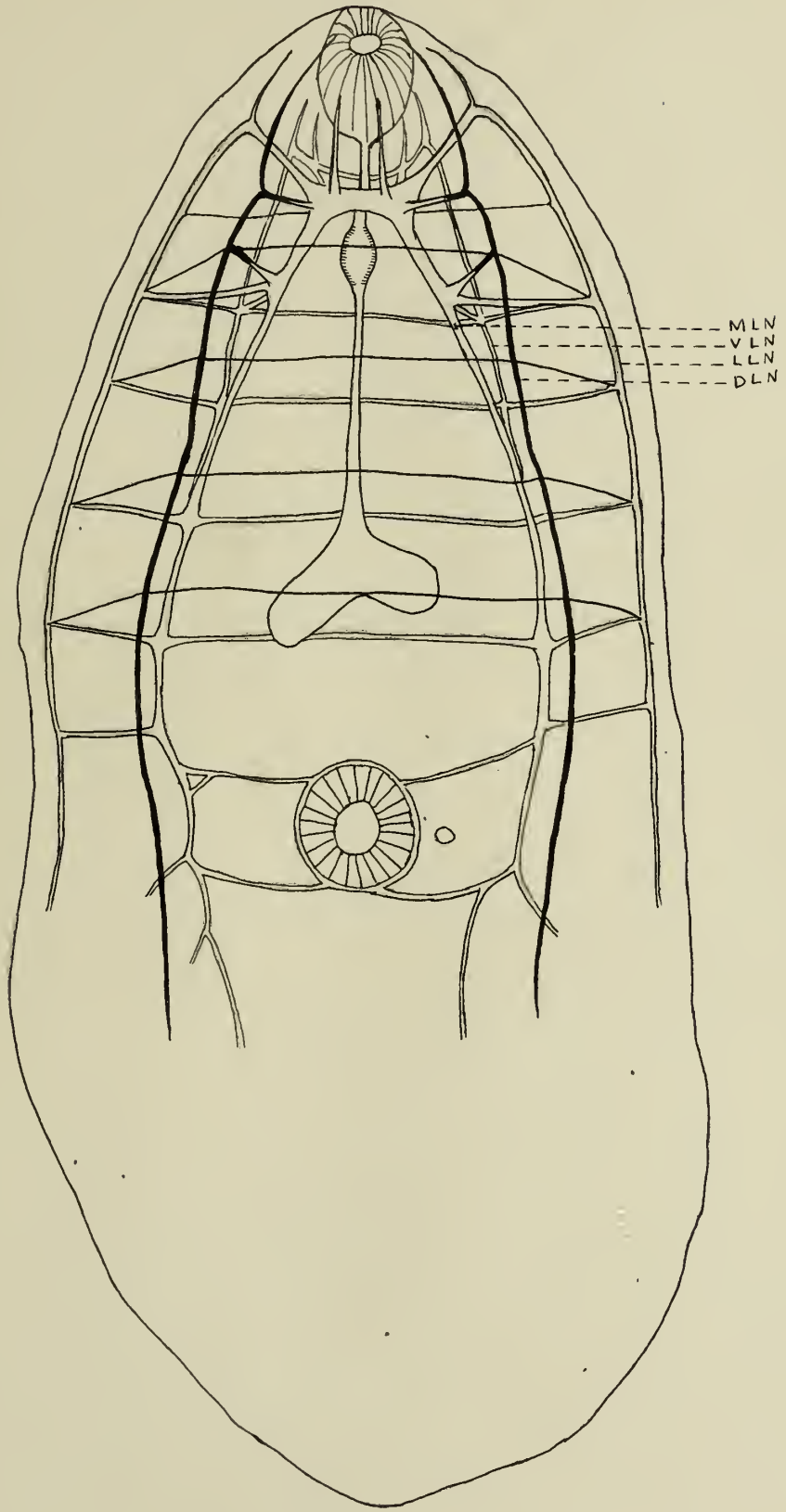

Fig. 35
Diagramatic